Residential Wood Boiler Technologies, Emissions Measurements, and Observations of Wood Smoke in Rural and Urban Communities in New York State

Clean Energy States Alliance webinar
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BIOMASS
Heating R&D
Heating and Cooling R&D
Environmental R&D

- Program and Policy Options
- Boiler Technology Development
- Technology Evaluation & Demonstration
- Test Method Development
- Ambient Air Quality & Health Effects
- Fuel Evaluation
- Communication
- Synergy with other NYSERDA activities
### Health Effects of PM2.5

#### Asthma and Increased Particle Levels
- Increase in Hospital Admission
- Decrease in Pulmonary Function
- Increase in Asthma Exacerbations
- Increase in Asthma Medication Use
- Increase in Pulmonary Mortality

#### Cardiovascular Responses to Air (Particles)
- Increased cardiac mortality
- Increased hospitalizations for CVD
- Increased hospitalizations for CHF
- Increased arrhythmia (Defibrillator intervention)
- Changes in heart rate and heart rate variability

11% asthma among children in NYS (Utell, 2007)
Outdoor wood boiler

Photo credit Phil Etter
“average PM” low but spikes frequently > 200 ug/m³, several over 400
Diurnal wood smoke in the Adirondacks

Running 3-h averages of 1-h data
Highest at night, lowest during the day

NYSERDA (2010a)
Localized high concentrations of wood smoke, “valley effect”
Wood smoke in Rochester, NY

Monroe County housing unit heating systems:
Natural gas (82.5%), Electricity (11.9%), Heating oil (2.9%), Propane (1.5%), Wood (0.5%)
Emissions testing of 4 wood-fired hydronic heaters by EPA ORD

- Conventional outdoor wood boiler (Red Oak, White Pine)
- Advanced outdoor wood boiler (Red Oak)
- Staged combustion (gasifier) with thermal storage (Red Oak)
- European pellet boiler (hardwood pellets)
- Each tested using the same “call for heat”

Aurell et al., 2012; Kinsey et al., 2012; Hays et al., 2012, ....
Outdoor Wood Boilers (Hydronic Heaters)

Conventional OWB
Updraft
250,000 Btu/h
196 gallons
Fuel charge: 254 lbs

Advanced OWB
Down-draft
160,000 Btu/h
450 gallons
Fuel charge 200 lbs

Btu = British Thermal Unit
2-stage combustion (gasification) wood boiler

downdraft
150,000 Btu/h
32 gallons
Fuel charge: 64 lbs
Staged combustion
137,000 Btu/h
43 gallons
pellets
Syracuse, NY heat load

Ranch-style home, 2500 ft²
R-13

NYSERDA (2012)
EPA-ORD residential wood boiler research

All units responding to the same heat load with no thermal storage except for the US downdraft

- Pellet: 0.08 lb/day
- Oil-fired boiler: 0.004 lb/day
- ULS HHO: 0.00004 lb/day

PM Generated per Syracuse Day for All Six Unit/Fuel Combinations.
Efficiency curve for pellet boiler
Determine the Heat Load

<table>
<thead>
<tr>
<th>Method</th>
<th>Details</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual J, Energy 10, DOE 2 etc</td>
<td>Insulation, solar gain, internal gains, temperature, infiltration, weather data etc</td>
<td>High</td>
</tr>
<tr>
<td>Square footage</td>
<td>How big is the house?</td>
<td>Low</td>
</tr>
<tr>
<td>Previous system</td>
<td>What was the output of the previous system?</td>
<td>Low</td>
</tr>
</tbody>
</table>

- Over sizing is very common

- NYSERDA programs require a Manual J (or equivalent) calculation to determine proper HVAC equipment sizing.
Boiler Sizing

- Sizing is a problem for all boilers and is especially challenging for solid fuels
- More challenging with larger fuel charge
- Auxiliary thermal storage serves as a major efficiency measure for staged combustion units resulting in lower emissions
- Pellet boilers also benefit from smaller buffer tanks
Development of test method for advanced cord wood boiler technologies with thermal storage
Thank you!
Symposium held in November 2011

Focus on industrial, commercial, and institutional applications (non-residential)

Broad stakeholder participation from 9 states:

- academia;
- state energy, environment, health, education, and forestry agencies;
- health advocacy; and
- biomass industry participants

State of the Science on Biomass Emissions and Health Effects

Recommendations and Priority Action Steps

http://www.sustainableproduction.org/WoodBiomass.php
PM 2.5 emissions on energy input basis

The Next Generation Wood Stove Design Challenge is now underway! The Challenge seeks to promote next generation stove designs, build a community of innovators and showcase stove innovation to the public.

Popular Mechanics

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References


